



THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Inventor/Appellant: Partho Sarkar

Title: CRACK-RESISTANT ANODE-SUPPORTED FUEL CELL

Application No. 10/658,803

Filed: September 9, 2003

Examiner/Art Unit: ALEJANDRO, Raymond / 1745

Attorney File No.: 2281-001-03

CERTIFICATE OF MAILING OR TRANSMISSION

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Rosanne F. Chow

APPEAL BRIEF

Dear Commissioner for Patents:

This is an appeal pursuant to 37 C.F.R. § 1.191(a) from the decision of the Examiner, dated June 5, 2006, finally rejecting claims 1-12 of the above-referenced patent application. A request for a one-month extension of time is enclosed pursuant to 37 C.F.R. 1.36(a).

Attached to this Brief as **Appendix A** is a claims appendix containing a copy of all the claims involved in the Appeal, as required under 37 C.F.R. §41.37(a)(viii). An evidence appendix as required under 37 C.F.R. §41.37(a)(ix) accompanies this Brief in the form of **Appendices B-E**. **Appendix B** contains pages from a publication that illustrates the oxygen ion conduction and high electrical conductivity characteristics of the solid electrolyte yttria stabilized zirconia ("YSZ") that make YSZ suitable for use in

the anode support layer of a solid oxide fuel cell ("SOFC"). **Appendix C** contains pages from a publication illustrating the relatively high electrical resistivity of alumina (aluminum oxide). **Appendix D** contains pages from a publication further discussing desirable characteristics of solid electrolytes suitable for use in SOFCs. **Appendix E** lists several Web sites that contain exemplary information illustrating the characterization and use of alumina as an insulator.

The objective evidence that accompanies this brief as **Appendices B-E** was made of record in the Response to final Office Action filed on October 11, 2006. This evidence was submitted after the final Office Action because this was when the Examiner first requested such evidence (See page of the Interview Summary mailed September 12, 2006). Thus, this evidence was necessary to fully respond to the Examiner's request and could not have been earlier presented since such a request had not been made until that point in the prosecution of the present application. These are certainly good and sufficient reasons pursuant to 37 C.F.R. § 1.116(e) and this evidence is therefore of record in the present application in accordance with 37 C.F.R. §41.37(c)(2).

A related proceedings appendix as required under 37 C.F.R. §41.37(c)(1)(ii) accompanies this brief as **Appendix F** and indicates there are no related appeals, interferences, or judicial proceedings, as is discussed in more detail in Section II below.

I. Real Party In Interest

The real party in interest is Alberta Research Council, Inc., having a principal place of business at 250 Karl Clark Road, Edmonton, Alberta T6N 1E4, Canada. The inventors assigned this application to Alberta Research Council, Inc. ("Assignee") in an Assignment recorded on February 9, 2004 at reel no. 014958, frame no. 0347.

II. Related Appeals and Interferences

Based on information obtained from Alberta Research Council, Inc., and based on information and belief of the undersigned attorney, there are no prior or pending

appeals, interferences, or judicial proceedings known to Appellant, Appellant's legal representative the undersigned attorney, or the Assignee, which are related to, which directly affect or which will be directly affected by, or which have a bearing on the decision of the Board of Patent Appeals and Interferences ("the Board") in the pending Appeal. There are no such appeals, interferences, or judicial proceedings as indicated in the related proceedings appendix that accompanies this brief as **Appendix F**.

III. ***Status of the Claims***

Claims 1-13 are pending and stand rejected by the Examiner. Claims 1-12 are appealed.

IV. ***Status of Amendments***

An Amendment After Final was filed on October 11, 2006 in response to a Final Office Action mailed on June 5, 2006. In an Advisory Action mailed on October 17, 2006, the Examiner indicated the proposed amendments in the Amendment After Final would not be entered as raising new issues that would require further consideration and/or search. **Appendix A** includes all the appealed claims 1-12 as they are currently pending.

V. ***Summary of the Invention Claimed Subject Matter***

This summary of the invention provides cross-referencing to the application as required by 37 C.F.R. § 41.37(c)(v). This cross-referencing is solely to assist the Board in understanding the Applicant's invention and is not meant to be exhaustive or to limit the scope of the pending claims.

Independent claim 1 recites an anode-supported solid oxide fuel cell including an anode support layer comprising a porous ion-conducting structure having pores impregnated with a catalytic and electronically conductive material. An electrolyte layer is in adjacent intimate contact with the anode support layer and a cathode layer is in adjacent intimate contact with the electrolyte layer.

Figure 1 illustrates a planar anode-supported solid oxide fuel cell 2 corresponding to one embodiment of present invention covered by claim 1. The anode-supported solid oxide fuel cell recited in claim 1 corresponds to the fuel cell 2 in the embodiment of Figure 2. See page 5, lines 25-30 and page 6, lines 1-3 (paragraph 16). The anode support layer recited in claim 1 corresponds to an anode support layer (ASL) 16 in the embodiment of the fuel cell 2 shown in Figure 2. *Id.* Claim 1 further recites that the anode support layer includes a porous ion-conducting structure having pores impregnated with a catalytic and electronically conductive material. This recited porous ion-conducting structure having pores impregnated with a catalytic and electronically conductive material is discussed on page 6, lines 16-30 and page 7, lines 1-2 (paragraph 19) with reference to the ASL 16. Claim 1 further recites an electrolyte layer that is in adjacent intimate contact with the anode support layer, where the recited electrolyte layer corresponds to an electrolyte layer 12 in the embodiment of Figure 1. *Id.* Finally, claim 1 recites a cathode layer that is in adjacent intimate contact with the electrolyte layer, where the recited cathode layer corresponds to a cathode layer 10 in the embodiment of Figure 2. *Id.*

Turning now to independent claim 12, this claim recites an anode-supported solid oxide fuel cell including a cathode layer in adjacent intimate contact with an electrolyte layer that is in adjacent intimate contact with an anode functional layer. The anode functional layer is in adjacent intimate contact with an anode support layer comprising an ion-conducting structure with a plurality of vias extending through the thickness of the oxygen ion-conducting structure, with at least some of the vias being filled with electronically conductive material.

Claim 12 covers, for example, the embodiment of the present invention illustrated in Figure 2. The anode-supported solid oxide fuel cell recited in claim 12 corresponds to the fuel cell 2 in the embodiment of Figure 2. See page 8, lines 22-30 and page 9, lines 1-3 (paragraph 24). Claim 12 further recites that the fuel cell includes a cathode layer in adjacent intimate contact with an electrolyte layer that is in adjacent intimate contact with an anode functional layer. The recited cathode layer, electrolyte layer, and anode functional layer correspond to a cathode layer 10, electrolyte layer 12,

and anode functional layer 14, respectively, in the embodiment of Figure 2. Claim 12 further recites that the anode functional layer, which corresponds to layer 14 in Figure 2, is in adjacent intimate contact with an anode support layer comprising an ion-conducting structure with a plurality of vias extending through the thickness of the oxygen ion-conducting structure, with at least some of the vias being filled with electronically conductive material. The recited anode support layer corresponds to the anode support layer 16 in the embodiment of Figure 2. *Id.* The recited plurality of vias extending through the thickness of the oxygen ion-conducting structure correspond to the vias 20 in the embodiment of Figure 2. *Id.*

VI. Issues/Grounds of Rejection to Be Reviewed On Appeal

1. Whether U.S. Patent Application Publication No. 2002/0164523 to Shibata et al. ("Shibata") anticipates claims 1-6, 9, and 11-12 under 35 U.S.C. § 102(e).
2. Whether claims 7-8 and 10 are obvious under 35 U.S.C. § 103(a) in view of the combination of Shibata and U.S. Patent Application Publication No. 2002/0028367 to Sammes et al. ("Sammes").

~~VII. Grouping of Claims~~

- ~~1. Claims 1-6, 9, 10, and 11-12 stand or fall together.~~
- ~~2. Claims 7 and 8 stand or fall together.~~

VIII. Argument

1. Claims 1-6, 9, and 11-12 are allowable under 35 U.S.C. § 102(e) over U.S. Patent Application Publication No. 2002/0164523 to Shibata et al. ("Shibata") because Shibata neither discloses nor suggests an anode support layer comprising a porous ion-conducting structure having pores impregnated with a

catalytic and electronically conductive material.

“Under 35 U.S.C. § 102, every limitation of a claim must identically appear in a single prior art reference for it to anticipate the claim.” *Gechter v. Davidson*, 42 USPQ2d 1030, 1032 (Fed. Cir. 1997). Before determining whether a prior art reference anticipates a claim, one must first construe the claim “to define the scope and meaning of each contested limitation.” *Id.* The proper starting place in any claim construction analysis is the claim language itself read in view of the specification and the prosecution history. *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (*en banc*).

In the final Office Action mailed 5 June 2006, the Examiner maintained the rejections of claims 1-6, 9, and 11-12 under 35 U.S.C. § 102(e) as being anticipated by Shibata. On September 7, 2006, the undersigned along with the inventor Partho Sarkar and Brian Y. Lee, Canadian counsel for the Assignee, held a telephone interview with the Examiner to discuss the rejections of the pending claims (See the Examiner's Interview Summary mailed September 12, 2006 that is part of the file history of the present application). During this telephone interview, the Examiner construed the “porous ion-conducting structure having pores impregnated with a catalytic and electronically conductive material” recited in claim 1 as corresponding to the porous metallic base body 1 illustrated in Figures 4-7. Paragraph 44 of Shibata states “it may be possible for the porous metallic base body [1] to be made of a ceramic which is plated with the above metals [e.g., nickel Ni] or with the alloy containing the above metals.” Paragraph 69 more specifically provides “the porous base body 1 ... includes a ceramic (alumina) body plated with [nickel] Ni.” In both the final Office Action (Item 2, bottom of page 3) and during the telephone interview, the Examiner erroneously concluded that the alumina portion of the base body 1 corresponds to the “porous ion-conducting structure” and the nickel Ni coating corresponds to the “catalytic and electronically conductive material” as recited in claim 1.

Notwithstanding the Examiner's assertions, alumina is not a porous ion-conducting material. This fact is well understood and known by those skilled in the art. Alumina is an insulator having a resistivity that is too high for this material to be

considered a solid electrolyte and an oxygen ion conductor suitable for use in a solid oxide fuel cell. In order for a material to be considered an oxygen ion conductor suitable for use in an electrode of a solid oxide fuel cell, the material must provide the necessary and efficient ionic path for anodic reaction which takes place during solid oxide fuel cell operation. As is well known in the solid oxide fuel cell art, the ionic conductivity of the anode must be comparable to the ionic conductivity of the electrolyte. Moreover, alumina's resistivity is too high at the operating temperature of a solid oxide fuel cell to perform the required electrode function for the fuel cell.

During the Examiner interview, the Examiner contended that even if alumina is considered in the prior art as an insulating material this material is nonetheless capable of conducting some ions, even if such ion conductivity is poor. See page 3 of the Interview Summary. The Examiner requested objective evidence to support that such an alumina ceramic is "incapable" of transporting ions, meaning that the material exhibits no ion conduction at all. *Id.*

A suitable material for the recited anode support layer and thus an ion-conducting material is yttria stabilized zirconia (YSZ). See, e.g., paragraph 8 of the present application. YSZ is an excellent conductor of negatively charged oxygen (oxide) ions at high temperatures. See paragraph 3. A solid oxide fuel cell operates at an elevated temperature, typically on the order of between 700-1000 °C. *Id.* See page 101 of the Suresh publication that accompanies this amendment as **Appendix B** regarding general characteristics of ion-conducting materials. Other oxygen ion conducting materials suitable for use in a solid oxide fuel cell may be substituted for YSZ in the anode support layer. See paragraph 19. A characteristic of a solid electrolyte, which may otherwise be known as a fast ion conductor or a superionic solid, is a high electrical conductivity in the range of 10^{-1} - 10^{-4} ohm⁻¹cm⁻¹ (i.e. a resistivity of 10-10,000 ohm⁻¹cm⁻¹). See page 17 of **Appendix B**. In contrast, alumina (aluminum oxide) has a resistivity of 5.0×10^8 at 700°C and 2×10^6 at 1000°C (see page 959 of the Shackelford and Alexander publication, which accompanies this amendment as **Appendix C**. This large resistivity of alumina plainly evidences that alumina is not a solid electrolyte/fast ion conductor/superionic solid suitable for use in a solid oxide fuel

cell. See the highlighted portions of the article that accompanies this amendment as **Appendix D** for additional information regarding desired resistivity values in fuel cells. **Appendix E** contains a listing of several Web sites that illustrate alumina being characterized and used as an insulator and not an ionic-conductor.

All the above evidence clearly demonstrates that the Examiner is in error in asserting that the alumina disclosed in Shibata corresponds to the recited porous ion-conducting material. Moreover, the Examiner's contention that because alumina must exhibit some ion conductivity the base body 1 of Shibata may be considered to correspond to the porous ion-conducting structure of the anode support layer recited in claim 1. Materials are classified as having physical characteristics that result in each material being placed in a particular class of materials, such as an electric or thermal conductor or insulator or an ionic conductor or insulator. Materials are not classified in absolute terms as would be required using the Examiner's logic. The Examiner requested evidence that "ceramic alumina is INCAPABLE of transporting ions (no ion conduction at all)." See page 3 of the Interview Summary. No such evidence can be provided for any material. Although classified as a particular type of material, every material will exhibit some characteristics of another class of materials. For example, materials classified as electrical insulators exhibit some amount of electrical conductivity, but such conductivity is so small that these materials are nonetheless classified as insulators. If the Examiner's argument was accepted, then the classification of materials would be rendered meaningless. Any material could be said to be whatever type of material was needed by an Examiner when formulating a rejection.

Pursuant to MPEP § 2111, during patent examination the pending claims must be given their broadest reasonable interpretation consistent with the specification. The Examiner expressly mentioned this well known tenet of patent examination during the Examiner interview. As expressly set forth in Section 2111, the "broadest reasonable interpretation of the claims must also be consistent with the interpretation that those skilled in the art would reach." As evidenced by the accompanying technical literature, one skilled in the art would not interpret the phrase "ion-conducting structure" to include

the insulating material of alumina ceramic. The Examiner's attempt to so interpret this phrase is simply put an unreasonable interpretation of this language. Although the Examiner cites the "broadest reasonable interpretation" language of Section 2111 as the rationale for his interpretation, such an interpretation of this language plainly in violation of this section of the MPEP as well as in contravention of common sense.

For all these reasons, Shibata neither discloses nor suggests an anode support layer comprising a porous ion-conducting structure having pores impregnated with a catalytic and electronically conductive material as recited in claim 1. The base body 1 of Shibata simply cannot be said to correspond to the recited anode support layer. As discussed above, an alumina ceramic simply is not "a porous ion-conducting structure." Because an alumina ceramic exhibits some ion conductivity does not make such an alumina ceramic an ion-conducting structure. As previously discussed with reference to **Appendices B-E**, alumina's resistivity is too high for this material to be considered a solid electrolyte and an ion conductor for a solid oxide fuel cell. Alumina's resistivity is also too high at the operating temperatures of solid oxide fuel cells to carry out the required electrode function.

Furthermore, claim 1 recites an electrolyte layer in intimate contact with the anode support layer. Shibata discloses electrodes 10 and 11 to be in intimate contact with the electrolyte and not the base body 1 asserted by the Examiner to correspond to the anode support layer. Thus, claim 1 is allowable for this additional reason.

For all these reasons, the combination of elements recited in claim 1 is allowable and dependent claims 2-11 are allowable for at least the same reasons as claim 1 and due to the additional limitations added by each of these claims.

Claim 12 recites an anode-supported solid oxide fuel cell comprising an anode support layer including an ion-conducting structure with a plurality of vias extending through the thickness of the oxygen ion-conducting structure. At least some of the vias are filled with electronically conductive material. An anode functional layer is in adjacent intimate contact with the anode support layer and an electrolyte layer is in adjacent intimate contact with the anode functional layer. A cathode layer is in adjacent intimate contact with the electrolyte layer.

Shibata neither discloses nor suggests an anode support layer as recited in claim 12. The base body 1 of Shibata simply cannot be said to correspond to the recited anode support layer since an alumina ceramic is not an oxygen ion-conducting structure. Simply because an alumina ceramic exhibits some ion conductivity does not make such an alumina ceramic an ion-conducting structure. Alumina's resistivity is too high for this material to be considered a solid electrolyte and an oxygen ion conductor for a solid oxide fuel cell and the resistivity is also too high at the operating temperatures to carry out the required electrode function.

For all these reasons, the combination of elements recited in claim 12 is allowable.

During the interview, the Examiner also raised what he termed a potential 35 U.S.C. § 112, paragraph 1, issue regarding the recitation of an ion-conducting structure in the claims and pointed to paragraph 19 of the specification to support his assertion that only a description of oxygen ion conducting materials is contained in the application. See page 3 of the Interview Summary. The Examiner states that "the invention, as presently claimed, may have a [Section] 112 issue (lack of adequate written support, and may be [sic] lack of enablement) because it clearly does not disclose, suggest or teach how "ANY" ion conducting material can be suitably used in the claimed anode structure." While not at issue here a brief reply to this comment is provided. It is the Examiner and not the Applicant that is inserting the word "any" before the claim term "ion-conducting structure" recited in claims 1 and 12. Claim terms must be construed in the context of the application. As expressly noted by the Examiner on page 3 of the Interview Summary, the present application (paragraph 19, lines 4-7) states "other oxygen ion conducting materials suitable for SOFC use and having a relatively similar thermal coefficient to the electrolyte, as is known in the art, may be substituted for YSZ." Claims 1 and 12 are directed to anode-supported solid oxide fuel cells. In the context of solid oxide fuel cells, one skilled in the art would understand the recited term "ion conducting structure" to relate to oxygen ions. No Section 112 issue exists.

2. Claims 7-8 and 10 are nonobvious under 35 U.S.C. § 103(a) in

view of the combination of Shibata and U.S. Patent Application Publication No. 2002/0028367 to Sammes et al. ("Sammes") since there is no disclosure or suggestion.

In the final Office Action, the Examiner rejected claims 7, 8 and 10 under 35 U.S.C. § 103(a) as being obvious in view of Shibata and Sammes. As discussed above, nothing in Shibata discloses or suggests the recited anode support layer. Furthermore, Sammes describes anode layers that comprise different ratios of electrochemically active substance. Sammes also describes a process for manufacturing a solid oxide fuel cell anode wherein YSZ powder is added to NiO powder and these materials are milled, extruded, dried and sintered together. As discussed above, one would expect a cross-sectional micrograph of the base body described in Sammes to reveal a porous structure comprising a homogenous composition within each layer. There is no suggestion in Sammes to impregnate catalytic and electronically conductive material into the pores of an anode support layer, thereby creating an anode support layer having a non-homogeneous porous structure.

Claim 7 recites the fuel cell of claim 5 wherein the catalytic and electronically conductive material is Ni-containing material and is compositionally graded through the thickness of the anode support layer, with a higher concentration of the Ni-containing material at one major surface of the anode support layer than the other. The recited porous structure is non-homogeneous in that the electronically conductive material of nickel Ni is compositionally graded through the thickness of the anode support layer. As a result, the anode support layer has a higher concentration of nickel Ni at one major surface than at the other major surface. Within the recited single anode support layer the electronically graded material is graded through the thickness of this single layer. Sammes discloses multiple layers with the concentration within each layer being homogeneous or constant and not graded. For these reasons, even if combined Shibata and Sammes do not teach or suggest the recited structure of claim 7. Claim 7 is accordingly allowable.

Claim 8 recites the fuel cell of claim 7 wherein the anode support layer further comprises a second conductive metal selected from the group of ferritic steel, super

alloy, and Ni-Ag alloy and which is concentrated at the major surface of the anode support layer having the lower concentration of Ni-containing material. Once again, Sammes neither discloses or suggest a single anode support layer having a nickel Ni concentration graded as recited in claim 7 and then a second conductive material concentrated at the major surface of the anode support layer having the lower concentration of nickel Ni as recited in claim 8. Claim 8 is accordingly allowable for these additional reasons.

3. Dependent Claims Not Specifically Addressed In Section VIII

All dependent claims not specifically addressed in this section are patentable by virtue of their respective dependencies from claims for which the Applicants have presented an argument for patentability.

VIII. Claims Appendix

Appendix A includes all the appealed claims 1-12 as they are currently pending.

IX. Evidence Appendix

Appendices B through E include all objective evidence that was made of record in the Response to Final Office Action filed on October 11, 2006.

X. Related Proceedings Appendix

Appendix F indicates there are no related appeals, interferences, or judicial proceedings, as is discussed in more detail in Section II above.

IXI. Conclusion

For the foregoing reasons, the Applicants request the Board to reverse the Examiner's rejection of claims 1-6, 9, and 11-12 under 35 U.S.C. § 102(e) and his rejection of claims 7, 8, and 10 under 35 U.S.C. § 103(a) and remand the application to the Examiner for issuance of claims 1-12.

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Dated: August 31, 2007

Respectfully submitted,

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Enclosures:

Appendices A-F
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10/658,803

09/09/2003

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EXAMINER

ART UNIT

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Please find below and/or attached an Office communication concerning this application or proceeding.

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**Notification of Non-Compliant Appeal Brief
(37 CFR 41.37)**

Application No.

10/658,803

Applicant(s)

SARKAR ET AL.

Examiner

Raymond Alejandro

Art Unit

1745

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

The Appeal Brief filed on 29 June 2007 is defective for failure to comply with one or more provisions of 37 CFR 41.37.

To avoid dismissal of the appeal, applicant must file an amended brief or other appropriate correction (see MPEP 1205.03) within **ONE MONTH or THIRTY DAYS** from the mailing date of this Notification, whichever is longer.

EXTENSIONS OF THIS TIME PERIOD MAY BE GRANTED UNDER 37 CFR 1.136.

1. ☒ The brief does not contain the items required under 37 CFR 41.37(c), or the items are not under the proper heading or in the proper order.
2. ☐ The brief does not contain a statement of the status of all claims, (e.g., rejected, allowed, withdrawn, objected to, canceled), or does not identify the appealed claims (37 CFR 41.37(c)(1)(iii)).
3. ☐ At least one amendment has been filed subsequent to the final rejection, and the brief does not contain a statement of the status of each such amendment (37 CFR 41.37(c)(1)(iv)).
4. ☐ (a) The brief does not contain a concise explanation of the subject matter defined in each of the independent claims involved in the appeal, referring to the specification by page and line number and to the drawings, if any, by reference characters; and/or (b) the brief fails to: (1) identify, for each independent claim involved in the appeal and for each dependent claim argued separately, every means plus function and step plus function under 35 U.S.C. 112, sixth paragraph, and/or (2) set forth the structure, material, or acts described in the specification as corresponding to each claimed function with reference to the specification by page and line number, and to the drawings, if any, by reference characters (37 CFR 41.37(c)(1)(v)).
5. ☐ The brief does not contain a concise statement of each ground of rejection presented for review (37 CFR 41.37(c)(1)(vi)).
6. ☐ The brief does not present an argument under a separate heading for each ground of rejection on appeal (37 CFR 41.37(c)(1)(vii)).
7. ☐ The brief does not contain a correct copy of the appealed claims as an appendix thereto (37 CFR 41.37(c)(1)(viii)).
8. ☐ The brief does not contain copies of the evidence submitted under 37 CFR 1.130, 1.131, or 1.132 or of any other evidence entered by the examiner and **relied upon by appellant in the appeal**, along with a statement setting forth where in the record that evidence was entered by the examiner, as an appendix thereto (37 CFR 41.37(c)(1)(ix)).
9. ☐ The brief does not contain copies of the decisions rendered by a court or the Board in the proceeding identified in the Related Appeals and Interferences section of the brief as an appendix thereto (37 CFR 41.37(c)(1)(x)).
10. ☐ Other (including any explanation in support of the above items):

1.) The heading "Summary of the invention" should read "Summary of the claimed subject matter". Also in the brief filed 02/12/07 the following headings should be changed. Issues should read "Grounds of rejection to be reviewed on appeal". The heading grouping of claims is no longer required by 41.37(c).

2.) The brief does not contain headings for the evidence and related proceedings appendix. If there is no evidence or related proceedings appendix, then the indication "none" should be included after both headings.

TIM COLE
PATENT APPEAL CENTER SPECIALIST

Timothy Cole

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